(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: 0 291 596 B1

(12) EUROPEAN PATENT SPECIFICATION

(45) Date of publication of patent specification: 19.01.94 (51) Int. Cl.5: G02B 3/14, G02B 26/08

(21) Application number: 87304564.5

(22) Date of filing: 22.05.87

(54) Suspension system for a flexible optical membrane.

(43) Date of publication of application:
23.11.88 Bulletin 88/47

(45) Publication of the grant of the patent:
19.01.94 Bulletin 94/03

(84) Designated Contracting States:
AT BE CH DE ES FR GR IT LI LU NL SE

(56) References cited:
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Description

This invention relates to a suspension system for holding under tension a flexible membrane employed as a boundary surface of a liquid lens of adjustable focus or a flexible membrane mirror and to a new design of liquid lens, the focal length of which can be altered by relative movement between component parts of the lens holder. The invention also relates to an adjustable focus mirror.

A liquid lens consists of at least one flexible transparent membrane which defines a boundary surface of a space that can be filled with a liquid. The liquid can be at a higher or lower pressure than the medium (usually air) contacting the other side of the membrane, the pressure difference across the membrane causing it to curve so that the liquid-filled space functions as a lens.

A membrane mirror consists of a flexible membrane suspended in a frame of circular or other shape and with a reflective coating on one or both sides. Pressure applied to the membrane causes it to assume an appropriate conformation and allow the reflective coating to function as a mirror.

For each device, the membrane requires to be appropriately supported while the required shape-deforming pressure is applied to it. The present invention provides a method of supporting a membrane, forming part of a liquid lens or flexible mirror, under tension and thus provides improved liquid lenses and mirrors.

There have been many proposals for supporting membranes between frame members which involve the use of compressible seals and examples of such supporting systems are to be found in DE-A-71710, US-A-4466706 and FR-A-914827. This invention relates to a system of supporting an optical membrane under conditions of radial tension.

According to this invention a flexible membrane arrangement comprising a flexible membrane intended to serve as a boundary surface of a liquid lens or a flexible membrane mirror, and a suspension system for said flexible membrane, comprising two identical rings supported opposite one another in an annular frame with the membrane placed between the two rings, and in which pressure is applied to the rings via the frame whereby a circumferential zone of each ring surrounding the said boundary surface is pressed against the membrane, is characterised in that each ring is resilient and initially makes a line of contact with the membrane, the two lines of contact confronting one another and in that the applied pressure causes each said line of contact to become an annular zone producing a net outwardly directed radial tension at all points in the membrane, and thus holding it in a flat condition under tension.

The preamble of this definition of the invention is derived from DE-A-71710.

Conveniently the resilient rings are identical rings of elastomeric material of circular cross-section (known as O-rings) but identical rings of elastomeric material of non-circular cross-section can also be used.

In place of solid O-rings, hollow O-rings can be used. The pressure in a hollow O-ring can be varied to modify the radial tensions induced by it. Hollow O-rings can be divided into two or more sealed sections of the same or different lengths whereby the properties of each section can be altered by gas or liquid pumped into them. By varying the pressure in different sections, unequal radial tensions can be induced in the supported membrane. This allows controllable compensation for unequal forces acting on the membrane, such as centrifugal forces (if the boundary surface is part of a rotating system) or gravitational forces.

The resilient ring may be held in its supporting frame but not attached to it. However, the ring may be bonded to a supporting frame or even be an integral part of it. Thus, for example a moulded frame of plastics material may have an extrusion with a semi-circular cross-section or a cross-section of some other appropriate shape extending from the frame in a position in which the resilient ring is required. To ensure adequate resilience, the extruded ring may be hollow.

The compression forces applied at different parts of the circumference of the annular frame can be varied. This will cause different radial tensions in different parts of the membrane and allow controllable compensation for unequal forces which might be acting on the membrane (such as the centrifugal or gravitational forces mentioned above).

The force on the supported membrane at any point where the rings contact it, is determined by the compression forces acting on the resilient rings and the diameter and cross-sectional shape of the rings. The local force on the resilient rings may be altered by changing any of these parameters.

In one convenient application of the system of the invention an adjustable liquid lens or mirror comprises a chamber delimited by a flexible membrane surface, a first fluid medium filling the chamber which, in the case of a lens, has a different refractive index from that of a second fluid medium contacting the other side of the flexible membrane, and an annular support member for the flexible membrane comprising relatively movable first and second component parts, the first and second component parts of the support member exhibiting closely adjacent cylindrical matching surfaces between which an O-ring seal is located and being adjustably linked in a fluid-tight manner whereby

the volume of the chamber is adjustable by moving one component part of the support member relative to the other along their common cylindrical axes in such wise as to vary the pressure in the first fluid medium and thereby to alter the shape of the said membrane surface, the membrane defining said membrane surface being held in place between a compressed pair of O-rings.

The lens or mirror desirably has the component parts of the support member screw-threaded together so that relative rotation of one in or on the other causes the required pressure change in the first fluid medium. Alternatively, one component part may fit into the other so that by sliding it in or out (by use of a ratchet or other means) the pressure may be altered accordingly.

The invention will now be further described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 shows, in schematic cross-section, a first embodiment of liquid lens in accordance with this invention,

Figure 2 shows, in cross-section, an alternative form of resilient ring for supporting a membrane in the lens of Figure 1,

Figure 3 illustrates the mode of operation of the resilient rings in supporting the membrane,

Figure 4 is a purely schematic sectional side elevation of a second embodiment of liquid lens according to the invention,

Figure 5 is a view similar to Figure 4 but of a two cavity liquid lens,

Figure 6 shows a schematic exploded sectional side elevation of a fourth embodiment of liquid lens according to the invention,

Figure 7 shows a partly sectioned side view of the assembled liquid lens of Figure 6, and

Figure 8 shows, in schematic sectional view, a pair of spectacles with two liquid lenses according to the invention.

Figure 1 shows a liquid lens formed between flexible membranes 10 and 11. The membranes in this example are of high-grade plastic foil (e.g. that known under the Trade Mark "Melinex") and have a thickness of some twelve microns. Each membrane is clamped between a pair of O-rings 13-16 supported in an annular frame made up of a body 17 and two end caps 18, 19. The O-rings are received in grooves in the frame and these are sized to ensure each O-ring is compressed (e.g. by 380 to 500 μm) against the respective membrane.

The body 17 is provided with a through-passage 20 through which a transparent liquid is fed into a space 21 defined within the body 17 between the membranes 10 and 11. A syringe (part shown at 22) can be connected to the passage 20 to vary the volume of liquid in the space 21 and thus vary the shape of the membranes 10, 11. The chain line 10a shows how the membrane 10 might appear with a reduced pressure in the space 21 and the line 11a how the membrane 11 might appear with a supra-atmospheric pressure in the space 21.

Each end cap 18, 19 is clamped to the body 17 by a number of fixing means 23. One of the fixing means has been shown as a screw 24 threaded into the body 17 and compressing the O-rings against the respective membrane via a spring 25. The spring 25 can be omitted and the screw 24 can be replaced by U-clamps or other fixing means.

Figure 2 shows a scrap section through part of the frame of a liquid lens, the membrane being shown at 10′, one end cap at 18′, part of the body at 17′, and the sealing rings at 13′, 14′. In this case, the rings 13′, 14′ are of non-circular cross-section and the grooves locating them are inclined to the axis of the aperture in the end cap 18′.

Figure 3 shows the cross-section of two O-rings 15′, 16′ with a membrane 11′ grasped between them. When downward pressure is applied on the upper ring 15′ at A, and upward pressure on the lower ring 16′ at B, the resultant forces in the plane of the membrane 11′ acting at the position of contact, C, tend to move this outward, in the direction of the arrow D. This causes radial stretching of the membrane 11′.

The membrane 10 (11) can be silvered on either or both of its upper and lower surfaces to create a mirror of variable curvature. In the case of a mirror, one of the membranes can be replaced by a non-flexible plate closing off the volume 21 and in the case of a lens, one of the flexible membranes 10 or 11 can be replaced by a rigid lens to make a two-part combination lens, one part of which is a liquid lens. Clearly locating a rigid lens in the space 21 between two flexible membranes will give rise to a three-part combination lens, the two outer parts of which are liquid lenses. Other combinations of liquid/solid lenses are clearly possible.

It is also possible to have liquid on the side of the membrane 10/11 outside the space 21, the latter containing a gas or a liquid with a different refractive index from that appearing outside the space 21.

Figure 4 (not drawn to scale) shows a further embodiment of adjustable power lens. An anterior flexible transparent membrane 31 is held in an outer part 33 of an annular holder 32 between a pair of O-rings 34 and 35. A posterior membrane 36 is held in a similar manner in an inner part 37 of the holder 32 by a further pair of O-rings 38, 39. The cavity 40 defined in the bore 41 of the holder between the membranes 31 and 36 is filled with a suitable liquid such as water, alcohol, gelatine or

glycerol, and an O-ring seal 42 prevents leakage of the filling liquid between the parts 33 and 37. The part 37 screws into the part 33 at 43. By screwing the holder part 37 towards or away from the holder part 33, the pressure in the cavity 40 can either be increased causing the membranes 31, 36 to flex outwardly and the liquid lens to become more positive, or reduced, causing the liquid lens to become more negative. The medium in contact with the upper surface of the membrane 31 and the lower surface of the membrane 36 would normally be air but it will be appreciated this need not be the case. The bore 11a could contain some other gas or even a liquid of different refractive index from that filling the cavity 40.

The means for turning part 37 relative to part 33 of the holder 32 to effect a lens power change can take many forms. It could, for example, be a knurled ring 44 surrounding part 33 and connected to part 37 via a rod 45 located in an arcuate slot 46 in the part 33. Displacement without rotation is also possible (e.g. with an external screw clamp).

Figure 5 shows a rather more complex liquid lens having two liquid lenses one above the other. Where appropriate the same reference numerals have been used in Figure 5 as were used in Figure 4 to designate similar integers. The compound adjustable membrane autofocus lens shown in Figure 5 has a third housing part 47 screw-threaded into the part 37 with a separate O-ring seal 48.

The third part 47 supports an O-ring tensioned third membrane 49 which defines a second cavity 50 inside the bore 31a. The third part 47 can be axially adjusted relative to the second part 37 to adjust the pressure in the liquid filling the cavity 50. This adjustment could be by way of a ring 51 operating in a manner similar to that described above for the ring 44. Since membrane 36 is now common to the cavities 40 and 50 adjustment of the pressure in one will have an effect on the power of the liquid lens defined by the other. This may be of advantage, but if not, can readily be compensated for by appropriate readjustment of the other ring 44 or 51. Different liquids can be used in the two cavities 40 and 50.

Figures 6 and 7 illustrate a lens of a relatively compact design. As with the previous designs there are two transparent membranes (e.g. 23 micron thickness type D "Mylar" (RTM) material) 31 and 36 (shown only in chain lines) tensioned between respective pairs of O-rings 34, 35 and 38, 39. The housing 32 comprises a pair of annular members 52 and 53 which when interengaged with the membranes in place define a fluid-tight chamber of variable volume. The O-rings 34, 35 are pressurised on either side of the membrane 31 by an annular fixing plate 52a and the O-rings 38, 39 are pressurised on either side of the membrane 36 by an annular fixing plate 53a. Both fixing plates are tightened in place to tension the respective "MYLAR" membrane by means of a ring of screws (only shown schematically at 54).

The annular members 52, 53 are sealed in fluid-tight manner by an O-ring 55 designed to be located in a groove 56 in a cylindrical outer surface 57 of the member 53. A part 58 of the surface 57 is screw-threaded to mesh with a threaded part 59 of a second cylindrical surface 60 forming part of the member 52. The size of the O-ring 55 and the dimensions of the groove 56 in which it is located are selected (in known manner) to obtain sufficient deformation of the O-ring to provide a good fluid-tight seal between the surfaces 57 and 60 but not so great a deformation as to make it difficult to occasion relative rotation between the members 52, 53 when the power of the lens is to be adjusted. The chamber 61 created in the member 52 by the seal 55 and the membranes 31 and 36 could be filled with air-free distilled water 62, for example as shown in Figure 7.

Figure 7 shows the Figure 6 embodiment fully assembled and arranged to provide a negative double-concave lens. The liquid 62 filling the chamber 61 between the membranes 31 and 36 is at sub-atmospheric pressure, the pressure being adjusted by screwing the member 53 into or out of the member 52. Screwing in will reduce the power of the negative lens and screwing out will increase the power of the lens.

It will be seen therefore that the lens constructions shown in Figures 4 to 7 each include a piston-type arrangement in which one housing member moves as a sealed piston within the other to provide a "pumpless" lens.

In each of the lens designs illustrated one of the membranes may be replaced by a substantially rigid solid fluid-tight transparent member which may or may not have a power different from unity.

A telephoto lens is a system of lenses designed to allow a camera to photograph a magnified image of distant objects. A zoom lens is a system of lenses which can be adjusted by altering the physical arrangement of the lens components therein so as to alter the overall focal length and field of view to give it telescopic or near-field properties. Autofocus lenses of the kind described above may be used in place of solid lenses in a telephoto or zoom lens, telescope, binoculars, microscope, camera, or other optical device. They may be used in combination with fixed lenses. Thus a zoom lens can be constructed of two adjustable membrane autofocus lenses in sequence, one having a negative and the other a positive power. The relative positions of the lenses do not require to be altered in order to change the focal length of the combination. This can be done by

rotating the inner or outer part of the holder of one or the other of the autofocus lenses.

If the anterior surface of a liquid lens (say membrane 31 in Figure 4) is covered with a reflective coating, this produces a flexible membrane mirror. By displacing the inner part 37 of the holder 32 in Figure 4, the focus of the membrane mirror 31 can be altered. A mirror of this construction can be considered to be an autofocus membrane mirror.

A pair of spectacles is a device consisting of two lenses in a frame that allows the lenses to be worn before the eyes so as to correct errors of refraction or supplement deficient accommodation. Spectacles are traditionally made with solid lenses. These have the disadvantage that the focal length is restricted (in the case of a bifocal lens to two values) and is not adjustable on demand. Figure 8 illustrates one possible design for spectacles in which the solid lenses have been replaced by autofocus lenses. The frame (shown at 70 in Figure 8) incorporates two holders 72, 72'. By rotating the inner parts 77 and 77' in the left and right lenses, the focus of each lens can be adjusted over a continuous range of values to suit the eye of the wearer for an object of regard at a given distance. The frame 70 may attach directly to the part 77, in which case the outer part 72 may fit on to part 77 by a screw- or slide-fitting.

Discs 81 and 82 of transparent unbreakable plastic or glass may be fixed to the rear and front of each liquid lens holder so as to protect the flexible membranes 71 and 76 from dirt and damage. The discs 81 and 82 may be clip-on or otherwise removable attachments (e.g. bayonet or screw mounted), or they could be permanently attached. The discs 81 and 82 may themselves be solid lenses that provide a basic correction to vision which can be further adjusted by altering the focal lengths of the liquid lenses. They may be planar, or they may have a cylindrical surface to allow for the correction of astigmatism. The surfaces of one or both discs may be so shaped as to correct for any aberrations associated with the liquid lens over a range of focal lengths. They may be transparent or tinted (e.g. light-intensity colour-controlled), so allowing the spectacles to be used as sunglasses of variable focus and variable tint. The spectacles of Figure 8 use liquid lenses of the kind shown in Figure 4 but other designs are clearly possible. Such spectacles may be embodied in a face mask or respirator so that adjustment may be made for the wearer's vision without requiring him to wear spectacles in addition to the mask.

This invention thus relates to novel types of liquid or semi-solid lenses which allow the focus of the lens to be altered directly by manipulating the relative positions of components of the holders of the lenses. Such lenses may be constructed of at least one membrane held between O-rings. Direct variation in the volume of the chamber delimited by the membrane(s) may be used to alter the internal pressure in the lens and so its focal length, giving a lens of directly adjustable focus. Such liquid lenses may be combined to produce compound lenses with both components separately adjustable or adjustable in some linked manner and they may be used to construct telescopes, zoom lenses, spectacles, cameras and a wide range of other optical devices.

If the means used for adjusting the pressure exerted on the membrane is calibrated in some way, the liquid lenses described above can be used by an opthalmologist in determining the refraction of a patient or by an optician in determining what power of spherical lens needs to be prescribed for each eye of a patient.

The calibration is conveniently arranged to read directly in dioptres but it is possible to have some other graduated scale and a reference chart to relate the scale readings to the appropriate lens power. Thus the arrangements described could be used to provide the calibration by marking a scale on one member and providing a pointer, line or other reference mark on the other, which moves along the scale as the lens power is changed.

It is envisaged that one or a few small disc-shaped liquid lenses such as that shown in Figure 6 could be used as replacement for the many fixed focus lenses normally used in prescribing spectacles and for other opthalmic purposes.

Further, if the focal length adjustment, in say the spectacles of Figure 8, is made sufficiently easy to operate and is manually accessible to a patient viewing through the liquid lenses, the patient can adjust the focal power to optimise the sharpness of focus he/she is experiencing during a test, thereby facilitating the selection of the correct lens power required to compensate for vision defects.

In case ageing of the membrane produces loss of calibration accuracy, a re-adjustment facility can be provided on each liquid lens to enable periodic re-calibration. For example, this could be a separate pre-settable pressure-adjusting means, or the pointer referred to above could be capable of having its position of attachment to the housing adjusted.

A cylindrical liquid lens of adjustable focus can be produced by using membranes of graded thickness and such liquid lenses can be used to correct astigmatic errors.

It is also possible to provide a liquid lens with an at least partial cylindrical lens by trapping the flexible membrane between confronting O-rings

held in respective grooves that follow cylindrical surfaces. Thus, for example, the grooves accommodating O-rings 34 and 35 in Figure 4, rather than being coplanar as shown, can each lie on a cylindrical surface, the O-ring 34 (say) lying on a first cylindrical surface of a given radius and the O-ring 35 lying on a second cylindrical surface of the same or substantially the same radius. In a pluri-chamber liquid lens, cylindrical components can be added to more than one of the membranes and the axes of the two or more different cylindrical components of the lens surfaces need not be parallel. The surfaces followed by a confronting pair of O-rings need not be cylindrical if they are non-planar thus leaving open the possibility of fabricating complex lens surface contours for specific applications.

Although the tensioned regions of the membranes disclosed thus far are circular in plan, there is no need for this to be the case and the invention should be seen to include non-circular tensioned membrane regions. In some applications a rectangular membrane could be used and such a membrane shape can be achieved either by using a rectangular O-ring (e.g. made from lengths of circular section elastomeric rod mitre-joined at the corners) or by using a pair of circumscribing circular O-rings to form the primary seal of the cavity to the membrane and to tension the membrane but contacting the tensioned membrane within the bore of the O-rings by a rectangular frame that defines the optical boundary of the liquid lens.

Claims

1. A flexible membrane arrangement comprising a flexible membrane (10) intended to serve as a boundary surface of a liquid lens or a flexible membrane mirror, and a suspension system for said flexible membrane, comprising two identical rings (13, 14) supported opposite one another in an annular frame with the membrane placed between the two rings, and in which pressure is applied to the rings via the frame whereby a circumferential zone of each ring surrounding the said boundary surface is pressed against the membrane (10), characterised in that each ring is resilient and and of such a shape that it makes initially a line of contact with the membrane, the two lines of contact confronting one another and that the applied pressure (A, B) causes each said line of contact to become an annular zone (C) producing a net outwardly directed radial tension (D) at all points in the membrane, and thus holding it in a flat condition under tension.

2. A flexible membrane arrangement as claimed in claim 1, characterised in that each ring is an elastomeric O-ring supported in a groove in a frame (18), each O-ring being compressed against the membrane by pressure applied to the frames.

3. A flexible membrane arrangement as claimed in claim 1, characterised in that two identical resilient rings (13', 14') are employed which are of non-circular cross-section and are located in grooves inclined outwardly in the direction towards the membrane.

4. A flexible membrane mirror characterised in that it makes use of a flexible membrane arrangement as claimed in any one of claims 1 to 3, and in that the membrane of said arrangement is reflective.

5. An adjustable liquid lens or mirror comprising a chamber (61) delimited by a flexible membrane surface (31), a first fluid medium (62) filling the chamber which, in the case of a lens, has a different refractive index from that of a second fluid medium contacting the other side of the flexible membrane, and an annular support member (32) for the flexible membrane comprising relatively movable first and second component parts (52, 53), the first and second component parts of the support member exhibiting closely adjacent cylindrical matching surfaces (57, 60) between which an O-ring seal (55) is located and being adjustably linked in a fluid-tight manner whereby the volume of the chamber is adjustable by moving one component part of the support member relative to the other along their common cylindrical axes in such wise as to vary the pressure in the first fluid medium (62) and thereby to alter the shape of the said membrane surface, the membrane defining said membrane surface being held in place between a compressed pair of O-rings (34, 35).

6. A lens or mirror as claimed in claim 5, characterised in that the first fluid medium is a transparent liquid, semi-solid or gelatinous substance.

7. A lens or mirror as claimed in claim 5 or claim 6, characterised in that the component parts of the support member are screw-threaded together so that relative rotation of one in or on the other causes the required pressure change in the first fluid medium.

8. A liquid lens as claimed in claim 5, 6 or 7, characterised by having two spaced-apart flexible membrane surfaces (31, 36) delimiting the

fluid-filled chamber (61), the relatively adjustable component parts of the membrane support member being screw-threaded together over part of interengaging cylindrical surfaces (43) with an O-ring (42) interposed between said surfaces (43), said O-ring defining a part of the boundary surface of said chamber, whereby rotation of one support member (33) part relative to the other (37) changes the pressure of the first fluid within the chamber and thus effects a change in shape of each flexible membrane surface, each membrane defining a membrane surface being held in place in its respective support member between a compressed pair of O-rings (34, 35: 38, 39).

9. A liquid lens as claimed in claim 8, characterised in that there are three flexible membranes (31, 36, 49) defining two adjacent fluid-filled chambers (40, 50) formed in a housing having outer (33), middle (37) and inner (47) components, one of said chambers being defined in part by a seal (42) formed between the outer and middle components and the other of said chambers being defined in part by a seal (48) formed between the middle and inner components, the third membrane also being held in place between a compressed pair of O-rings.

10. A liquid lens as claimed in claim 9, characterised in that relative movement is possible between the middle (37) and outer (33) components to vary the volume of the said one chamber (40) and relative movement is possible between the middle (37) and inner (47) components to vary the volume of the said other chamber (50).

11. A pair of spectacles, goggles, a face mask or a respirator comprising two liquid lenses as claimed in any one of claims 5 to 10 mounted in a frame (70).

12. The combination of a lens as claimed in any one of preceding claims 5 to 10 with a further lens to provide a telephoto or zoom lens, a telescope, binoculars, a microscope or a camera.

Patentansprüche

1. Anordnung für eine flexible Membran, die eine flexible Membran (10) umfaßt, die als Grenzfläche einer Flüssigkeitslinse oder eines Spiegels mit flexibler Membran dienen soll, sowie eine Halterung für die flexible Membran, die zwei identische Ringe (13, 14) umfaßt, die sich gegenüber in einem ringförmigen Rahmen mit zwischen den beiden Ringen angebrachter Membran gehalten werden, und bei der über den Rahmen Druck auf die Ringe ausgeübt wird, wodurch ein Umfangsbereich jedes die Grenzfläche umgebenden Rings gegen die Membran (10) gepreßt wird, dadurch gekennzeichnet, daß jeder Ring elastisch und derartig gestaltet ist, daß er anfangs eine Berührungslinie mit der Membran bildet, wobei sich die beiden Berührungslinien gegenüberstehen, und daß durch den ausgeübten Druck (A, B) jede dieser Berührungslinien ein ringförmiger Bereich (C) wird, wobei an allen Stellen in der Membran eine nach außen gerichtete Nettoradialspannung (D) erzeugt und die Membran somit unter Spannung in einem flachen Zustand gehalten wird.

2. Anordnung für eine flexible Membran nach Anspruch 1, dadurch gekennzeichnet, daß es sich bei jedem Ring um einen in einer Nut in einem Rahmen (18) gehaltenen elastomeren O-Ring handelt, der durch auf die Rahmen ausgeübten Druck gegen die Membran gedrückt wird.

3. Anordnung für eine flexible Membran nach Anspruch 1, dadurch gekennzeichnet, daß zwei identische elastische Ringe (13', 14') nicht-runden Querschnitts verwendet und in Nuten angebracht werden, die nach außen zur Membran hin geneigt sind.

4. Spiegel mit flexibler Membran, dadurch gekennzeichnet, daß er eine nach einem der Ansprüche 1 bis 3 beanspruchte Anordnung für eine flexible Membran benutzt und daß die Membran dieser Anordnung reflektierend ist.

5. Einstellbare(r) Flüssigkeitslinse oder Spiegel, die/der folgendes umfaßt: eine von einer flexiblen Membranfläche (31) begrenzte Kammer (61), ein erstes die Kammer füllendes strömungsfähiges Medium (62), das bei einer Linse eine von der eines zweiten strömungsfähigen Mediums, das die andere Seite der flexiblen Membran berührt, verschiedene Brechzahl aufweist, und ein ringförmiges Stützglied (32) für die flexible Membran, das relativ zueinander bewegliche erste und zweite Bauteile (52, 53) umfaßt, die eng benachbarte, zusammenpassende zylindrische Flächen (57, 60) aufweisen, zwischen denen eine O-Ring-Dichtung (55) angebracht ist, und die flüssigkeitsdicht in einstellbarer Weise verbunden sind, wobei das Volumen der Kammer durch derartiges Bewegen des einen Bauteils des Stütz-

glieds gegenüber dem anderen entlang ihrer gemeinsamen zylindrischen Achse eingestellt werden Kann, daß der Druck im ersten strömungsfähigen Medium (62) geändert und dadurch die Form der Membranfläche verändert wird, wobei die die Membranfläche definierende Membran zwischen einem zusammengepreßten Paar O-Ringe (34, 35) festgehalten wird.

6. Linse oder Spiegel nach Anspruch 5, dadurch gekennzeichnet, daß es sich bei dem ersten strömungsfähigen Medium um eine durchsichtige flüssige, halbfeste oder gelatinöse Substanz handelt.

7. Linse oder Spiegel nach Anspruch 5 oder 6, dadurch gekennzeichnet, daß die Bauteile des Stützglieds miteinander verschraubt sind, so daß eine relative Drehung des einen in oder auf dem anderen die erforderliche Druckänderung im ersten strömungsfähigen Medium verursacht.

8. Flüssigkeitslinse nach Anspruch 5, 6 oder 7, gekennzeichnet durch zwei voneinander beabstandete flexible Membranflächen (31, 36), die die mit dem Fluid gefüllte Kammer (61) begrenzen, wobei die relativ zueinander einstellbaren Bauteile des Membranstützglieds über Teil der ineinandergreifenden zylindrischen Flächen (43) verschraubt sind und ein O-Ring (42) zwischen den Flächen (43) eingesetzt ist, der einen Teil der Grenzfläche der Kammer definiert, wodurch Drehung eines Teils (33) des einen Stützglieds relativ zu dem anderen (37) den Druck des ersten Fluids in der Kammer ändert und somit eine Änderung der Form jeder flexiblen Membranfläche bewirkt, wobei jede eine Membranfläche definierende Membran zwischen einem zusammengepreßten Paar O-Ringe (34, 35;38, 39) in ihrem jeweiligen Stützglied festgehalten wird.

9. Flüssigkeitslinse nach Anspruch 8, dadurch gekennzeichnet, daß drei flexible Membranen (31, 36, 49) zwei benachbarte, mit einem Fluid gefüllte Kammern (40, 50) definieren, die in einem Gehäuse mit äußeren (33), mittleren (37) und inneren (47) Komponenten ausgebildet sind, wobei eine der Kammern teilweise von einer zwischen der äußeren und mittleren Komponente ausgebildeten Dichtung (42) und die andere Kammer teilweise von einer zwischen der mittleren und inneren Komponente ausgebildeten Dichtung (48) definiert wird und die dritte Membran auch zwischen einem zusammengepreßten Paar O-Ringe festgehalten wird.

10. Flüssigkeitslinse nach Anspruch 9, dadurch gekennzeichnet, daß eine Relativbewegung zwischen der mittleren (37) und äußeren (33) Komponente möglich ist, um das Volumen der einen Kammer (40) zu ändern, und eine Relativbewegung zwischen der mittleren (37) und inneren (47) Komponente möglich ist, um das Volumen der anderen Kammer (50) zu ändern.

11. Brille, Schutzbrille, Gesichtsmaske oder Atemschutzgerät, die zwei in einem Rahmen (70) eingesetzte Flüssigkeitslinsen nach einem der Ansprüche 5 bis 10 umfassen.

12. Kombination aus einer Linse nach einem der vorhergehenden Ansprüche 5 bis 10 mit einer weiteren Linse zur Schaffung eines Teleobjektivs oder Zoom-Objektivs, eines Fernrohrs, eines Fernglases, eines Mikroskops oder eines Fotoapparats.

Revendications

1. Dispositif à membrane flexible comportant une membrane flexible (10) destinée à servir de surface de délimitation d'une lentille liquide ou d'un miroir à membrane flexible, et système de suspension pour ladite membrane flexible comportant deux anneaux identiques (13, 14) supportés en regard l'un de l'autre dans une monture annulaire, la membrane étant placée entre les deux anneaux, et dans lequel on applique de la pression aux anneaux par l'intermédiaire de la monture, une zone circonférentielle de chaque anneau entourant ladite surface de délimitation étant ainsi pressée contre la membrane (10), caractérisé en ce que chaque anneau est élastique et de forme telle qu'il établisse initialement une ligne de contact avec la membrane, les deux lignes de contact se faisant face et que la pression appliquée (A, B) fait que chaque dite ligne de contact devient une zone annulaire (c) produisant une tension radiale (D) nette dirigée vers l'extérieur en tous points de la membrane, et donc la maintenant à plat sous tension.

2. Dispositif à membrane flexible selon la revendication 1, caractérisé en ce que chaque anneau est un joint torique élastomère, supporté par une rainure dans une monture (18), chaque joint torique étant comprimé contre la membrane par la pression appliquée aux montures.

3. Dispositif à membrane flexible selon la revendication 1, caractérisé en ce que l'on emploie

deux anneaux élastiques identiques (13', 14') de section transversale non-circulaire et qui sont situés dans des rainures inclinées vers l'extérieur en direction de la membrane.

4. Miroir à membrane flexible, caractérisé en ce qu'il utilise un dispositif à membrane flexible selon l'une quelconque des revendications 1 à 3, et en ce que la membrane dudit dispositif est réfléchissante.

5. Miroir ou lentille liquide ajustable comportant une chambre (61) délimitée par la surface (31) d'une membrane flexible, un premier milieu fluide (62) remplissant la chambre, qui, dans le cas d'une lentille, a un indice de réfraction différent de celui d'un deuxième milieu fluide en contact avec l'autre côté de la membrane flexible, et un organe support annulaire (32) pour la membrane flexible comportant des première et seconde pièces constituantes (52, 53) mobiles l'une par rapport à l'autre, les première et seconde pièces constituantes de l'organe support présentant des surfaces cylindriques conjuguées très proches l'une de l'autre (57, 60) entre lesquelles est situé un joint d'étanchéité torique (55) et étant raccordées de manière ajustable et étanche, le volume de la chambre pouvant être ainsi ajusté en déplaçant une pièce constituante de l'organe support par rapport à l'autre le long de leurs axes cylindriques communs de manière à faire varier la pression dans le premier milieu fluide (62) et donc à modifier la forme de ladite surface de membrane, la membrane définissant ladite surface de membrane étant maintenue en place entre une paire de joints toriques comprimée (34, 35).

6. Lentille ou miroir selon la revendication 5, caractérisé en ce que le premier milieu fluide est un liquide transparent, une substance semi-solide ou gélatineuse.

7. Lentille ou miroir selon la revendication 5 ou la revendication 6, caractérisé en ce que les pièces constituantes de l'organe support sont filetées ensemble de sorte qu'une rotation relative de l'une dans ou sur l'autre provoque le changement de pression souhaité dans le premier milieu fluide.

8. Lentille liquide selon la revendication 5, 6 ou 7, caractérisée en ce qu'elle a deux surfaces (31, 36) séparées de membrane flexible délimitant la chambre (61) remplie de fluide, les pièces constituantes ajustables l'une par rapport à l'autre de l'organe support de la membrane étant filetées ensemble sur une partie des surfaces cylindriques (43) engagées l'une dans l'autre avec un joint torique (42) interposé entre lesdites surfaces (43), ledit joint torique définissant une partie de la surface de délimitation de ladite chambre, la rotation d'une partie de l'organe support (33) par rapport à l'autre (37) changeant ainsi la pression du premier fluide au sein de la chambre et donc provoquant un changement de la forme de chaque surface de membrane flexible, chaque membrane définissant une surface de membrane étant maintenue en place dans son organe support respectif entre une paire de joints toriques comprimée (34, 35; 38, 39).

9. Lentille liquide selon la revendication 8, caractérisée en ce qu'il y a trois membranes flexibles (31, 36, 49) définissant deux chambres adjacentes (40, 50) remplies de fluide formées dans un logement ayant des constituants externe (33), intermédiaire (37) et interne (47), l'une desdites chambres étant définie en partie par un joint d'étanchéité (42) formé entre les constituants externe et intermédiaire, et l'autre desdites chambres étant définie en partie par un joint d'étanchéité (48) formé entre les constituants intermédiaire et interne, la troisième membrane étant également maintenue en place entre une paire de joints toriques comprimée.

10. Lentille liquide selon la revendication 9, caractérisée en ce qu'un mouvement relatif est possible entre les constituants intermédiaire (37) et externe (33) pour faire varier le volume de ladite une chambre (40) et qu'un mouvement relatif est possible entre les constituants intermédiaire (37) et interne (47) pour faire varier le volume dans ladite autre chambre (50).

11. Paire de lunettes, lunettes protectrices, masque antipoussière ou respirateur comportant deux lentilles liquides selon l'une quelconque des revendications 5 à 10, montées dans une monture (70).

12. Combinaison d'une lentille selon l'une quelconque des revendications 5 à 10 précédentes avec une autre lentille, pour produire un téléobjectif ou un zoom, un télescope, des jumelles, un microscope ou un appareil photographique.

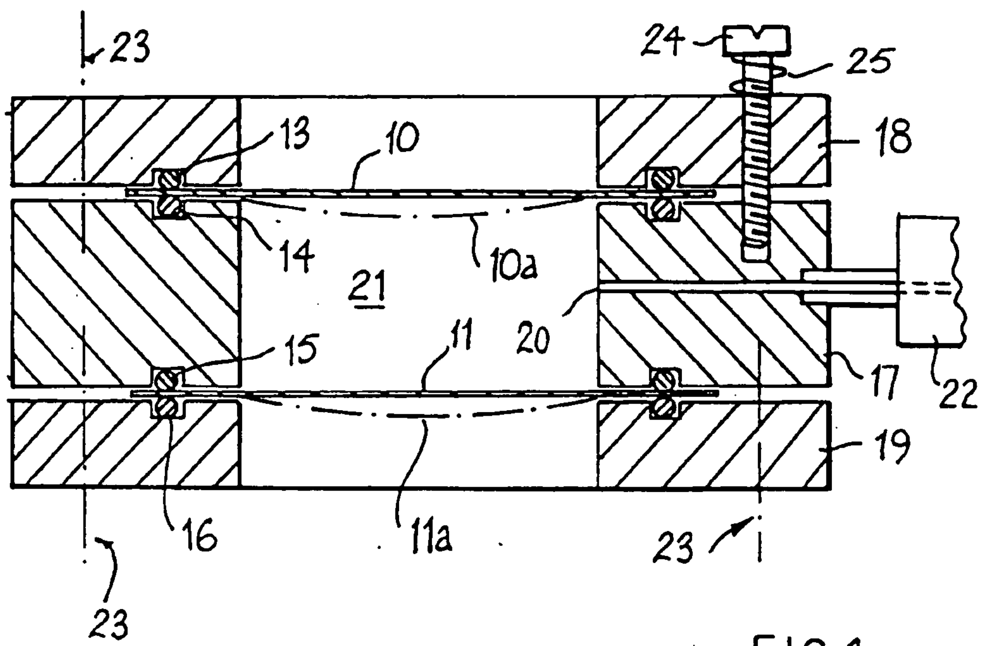

FIG.1

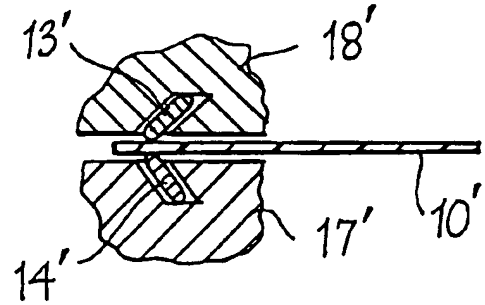

FIG.2

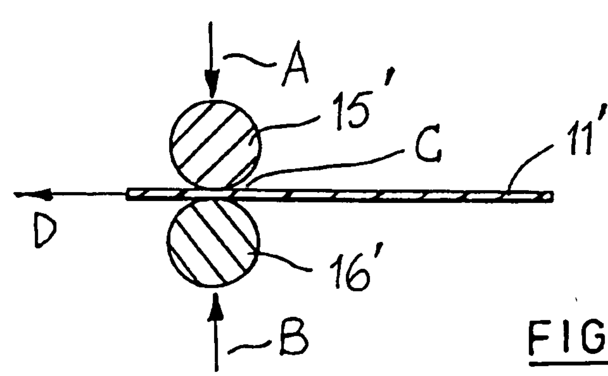

FIG.3

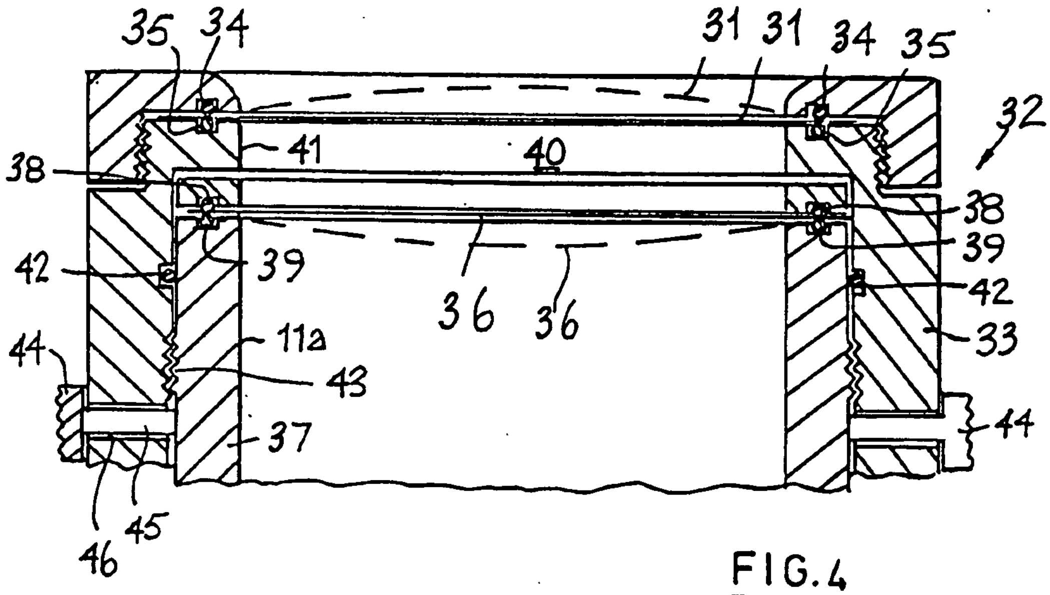
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FIG. 4

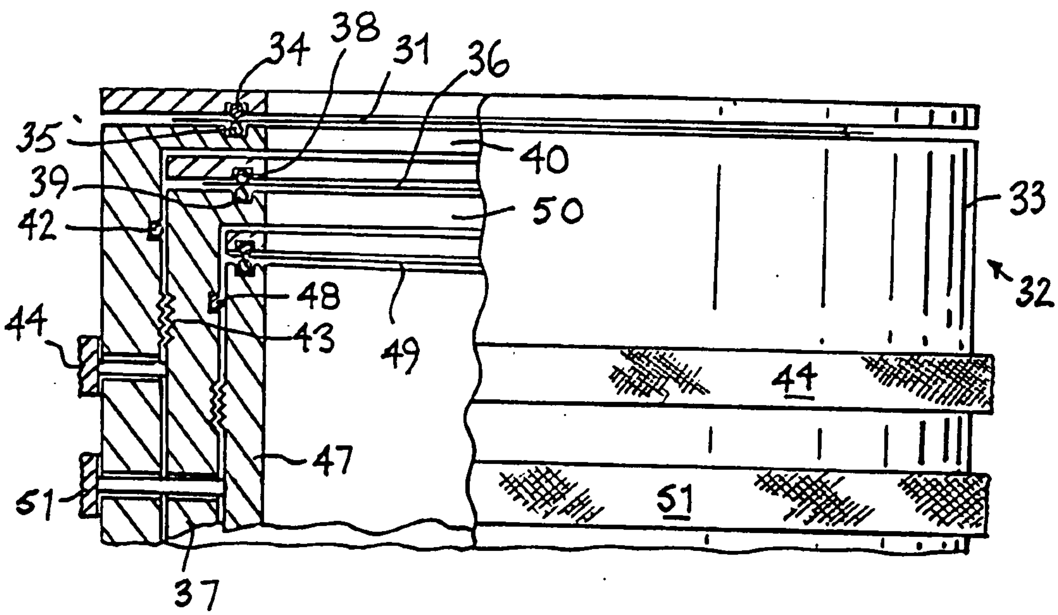
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FIG. 5

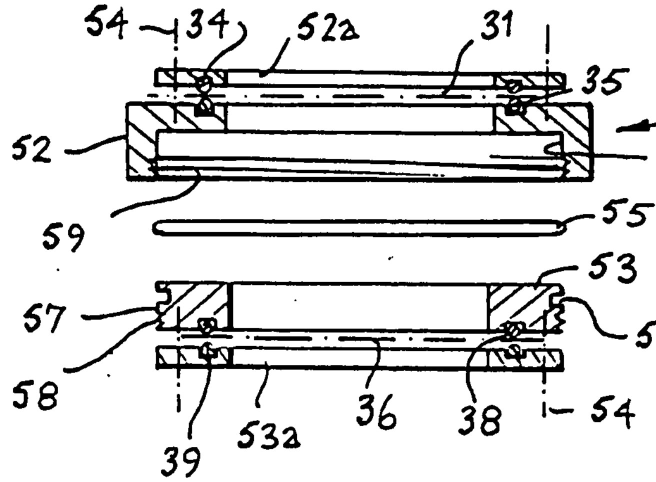

FIG.6

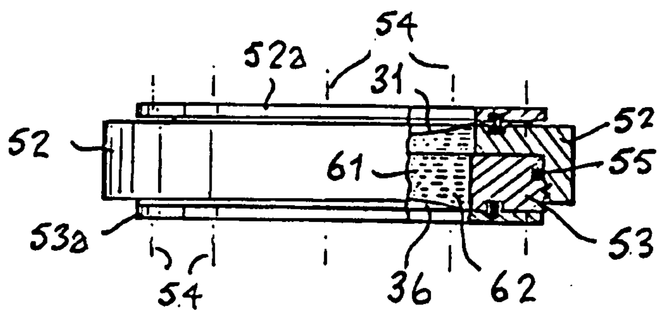

FIG. 7

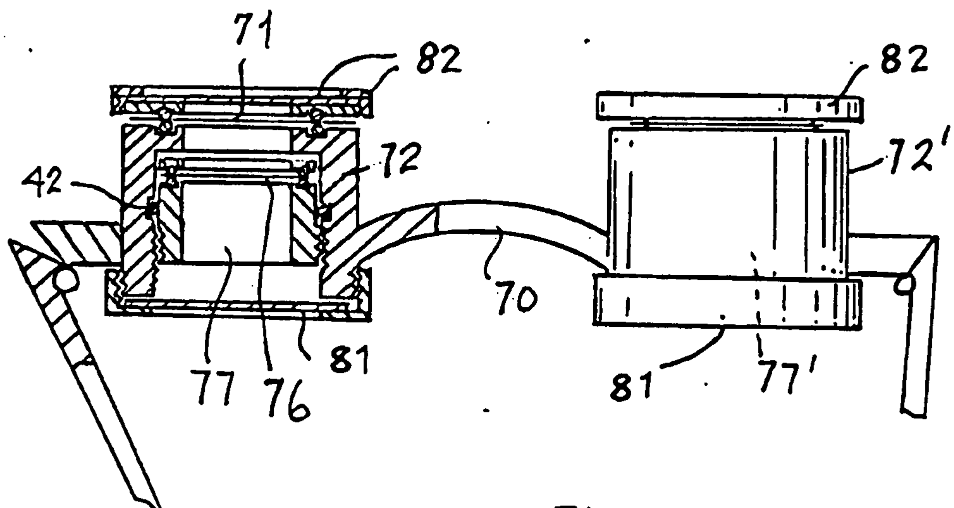

FIG.8